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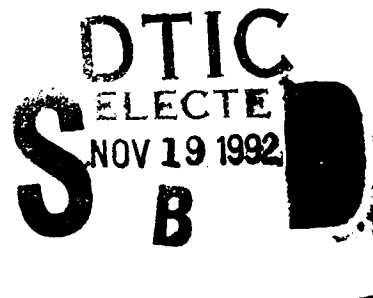
DRIFT SCINTILLATION METER FOR THE DEFENSE METEOROLOGICAL SATELLITE PROGRAM

B. J. Holt

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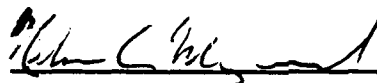12 January 1988–30 September 1992

PHILLIPS LABORATORY
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AIR FORCE MATERIEL COMMAND
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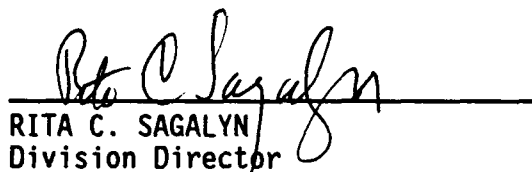"This technical report has been reviewed and is approved for publication"

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This is the final report for the subject contract under which the University of Texas at Dallas (UTD) has built, tested, and delivered the fifth instrument of the Drift Scintillation Meter (DSM2) to the Geophysics Laboratory for flight on Air Force DMSP satellites. The report is divided into three sections. Section 1 contains the instrument description and theory of operation. Section 2 contains a description of spacecraft level instrument testing, stimulation requirements, and instrument handling and safety. Section 3 contains a list of the schematics, drawings, parts lists, and wiring lists that describes the as-built configuration of the instrument.

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Preface

This is the final report for the subject contract under which The University of Texas at Dallas (UTD) built, tested, and delivered the fifth instrument of the Drift Scintillation Meter (DSM2) to the Geophysics Laboratory for flight on Air Force DMSP satellites. The report is divided into three sections. Section 1 contains the instrument description and theory of operation. Section 2 contains a description of spacecraft level instrument testing, stimulation requirements, and instrument handling and safety. Section 3 contains a list of the schematics, drawings, parts lists, and wiring lists that describes the as-built configuration of the instrument. This documentation is available to GL upon request. Test results, calibration data, and procedures are found in the R&D Equipment Information Report that was submitted to GL after the instrument delivery.

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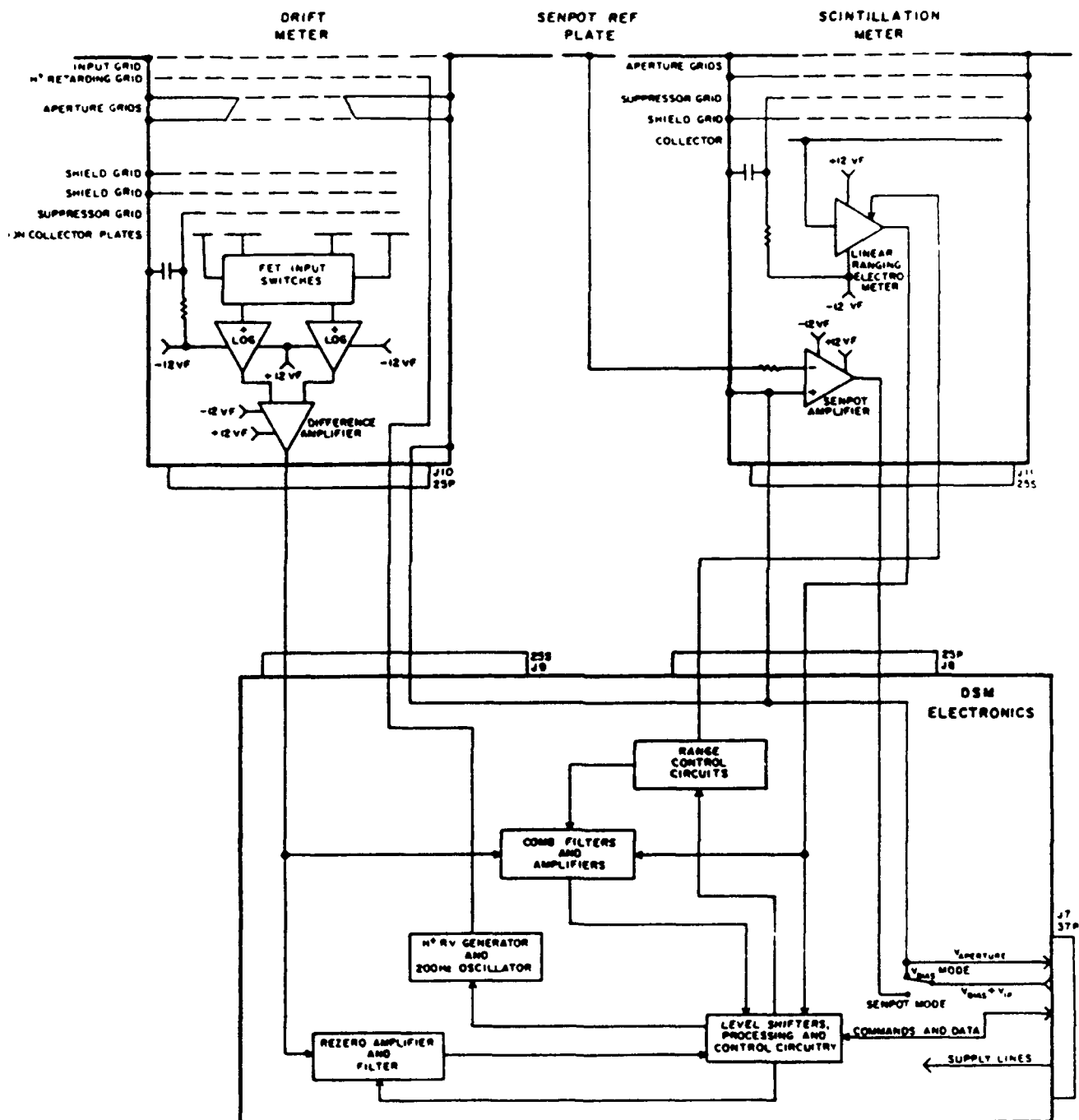
RELATED CONTRACTS

SECTION 1

INSTRUMENT DESCRIPTION

1.0 GENERAL

The Drift Scintillation Meter (DSM2) consists of a Drift Meter sensor, a Scintillation Meter sensor and an electronics box, as shown in Figure 1. The Drift Meter sensor and the Scintillation Meter sensor are mounted in a common mount and share a common aperture plane with the AFGL SSIES Ion (RPA) sensor. The DSM2 electronics box interconnects to the SSIES electronics box. Electrometer amplifiers are located in each sensor and the sensors connect to the DSM2 electronics box via AFGL-supplied cables. The DSM electronics box receives regulated voltages, digital commands, and timinsignals from the SSIES and outputs analog data on three lines to the SSIES. The three analog outputs are A/D converted by a 9 bit A/D converter. Figure 2 illustrates the time relationship for the sampling of the three outputs. The data collected each second from the three channels is sequentially telemetered as shown in Figure 2A. The three outputs and their sampling frequencies are:

    (1.)   Electrometer/Amplifier (E/A) – 24 samples/sec.

    (2.)   Drift Meter (DM) – 12 samples/sec.

    (3.)   Multiplex (MUX) – 12 samples/sec.

Since the DMSP satellite solar panels have a negative ground, the spacecraft can acquire a large negative potential in sunlight, thus requiring that the sensors be isolated from the spacecraft chassis and driven to a potential near the ambient plasma potential. A sensor potential circuit (SENPOT) that senses the ambient plasma potential and drives the sensors to a desirable potential ($V_{aperture}$) near that of the ambient plasma is provided as an auxiliary means of establishing the sensor potential. The SENPOT device is described in detail by Zuccaro and Holt (1982).[1]

2

DRIFT
METER

SENPOT REF
PLATE

SCINTILLATION
METER

INPUT GRID
H⁺ RETARDING GRID

APERTURE GRIDS

SHIELD GRID
SHIELD GRID
SUPPRESSOR GRID
ION COLLECTOR PLATES

FET INPUT
SWITCHES

LOG
LOG

-12 VF
-12 VF

+12 VF

-12 VF
+12 VF

DIFFERENCE
AMPLIFIER

J10
25P

APERTURE GRIDS
SUPPRESSOR GRID
SHIELD GRID
COLLECTOR

+12 VF

LINEAR
RANGING
ELECTRO
METER

-12 VF

-12 VF
+12 VF

SENPOT
AMPLIFIER

J11
25S

25S
J8

25P
J8

DSM
ELECTRONICS

RANGE
CONTROL
CIRCUITS

COMB FILTERS
AND
AMPLIFIERS

H⁺ RV GENERATOR
AND
200Hz OSCILLATOR

REZERO AMPLIFIER
AND
FILTER

LEVEL SHIFTERS,
PROCESSING AND
CONTROL CIRCUITRY

J7
37P

V_APERTURE
V_BIAS
MODE
V_BIAS + V_IP

SENPOT MODE

COMMANDS AND DATA

SUPPLY LINES

DSM2
FUNCTIONAL DIAGRAM

Figure 1
3

DSM2 DATA SAMPLE TIMES

Figure 2

4

SSIES - 2 DOWNLINK FORMAT

MARCH 10, 1986

WORD												ELECTRON MONITOR	
	CYCLE 1 ID	CONFIG 1 ID	CMD MON OLS	CURRENT MONITOR	RPA Thermistor	Vaporture MONITOR	RPA ION MONITOR	T_H+	T_O+	V_P RPA		T_E
	CYCLE 2 ID	CONFIG 2 ID	CMD MON DSM	TEMP. MONITOR	ELECTRON Thermistor	Bias MONITOR	SPARE	N_H+	N_O+	V_SP	V_P ELE	N_E
1-12												
13-24	RPA ION											
25-36	RPA ION											
37-48	DSM (ELE/AMP)											
49-60	DSM (DRIFT)											
61-72	DSM (Multiplex)											
73-84	DSM (ELE/AMP)											
85-96	ELECTRON											
97-108	ELECTRON											
109-120	RPA SWEEP					ELECTRON SWEEP						

☐ PROPOSED REDUCTION IN DOWNLINK DATA

⋮ ION AND ELECTRON DATA CAN BE INTERCHANGED BY COMMAND
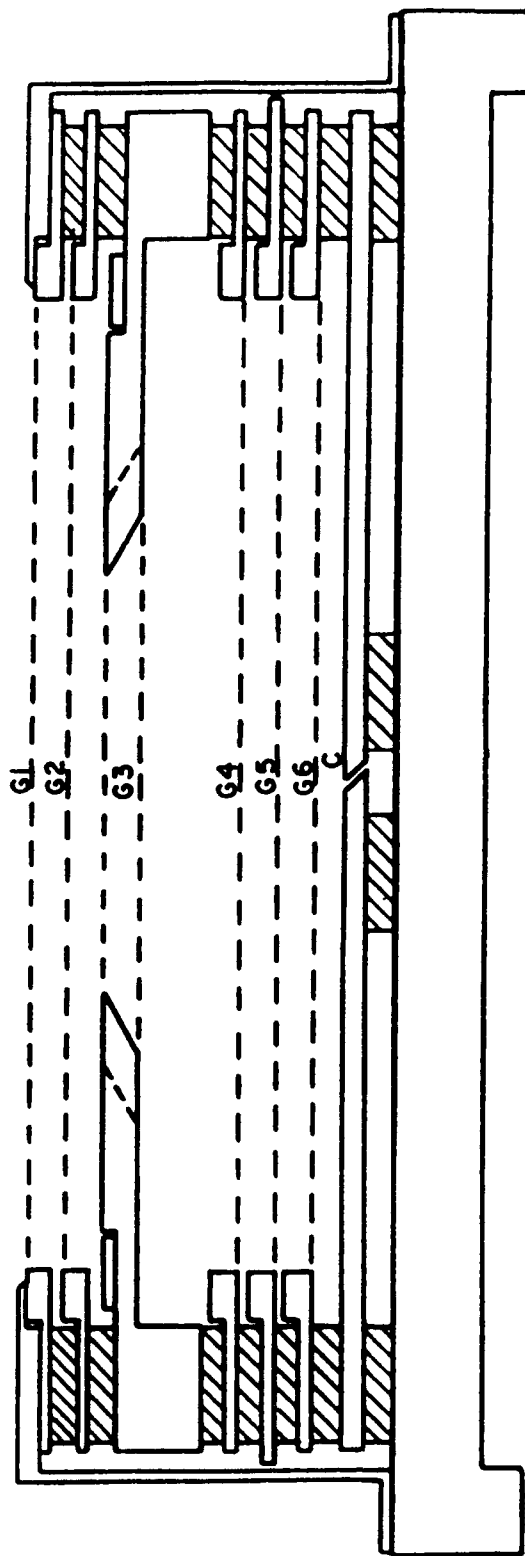
Figure 2A

PRR1 SSIES-2 FORMAT

5

2.0 PRINCIPLES OF OPERATION

2.1. Drift Meter

The Drift Meter (DM) employs a gridded collimator and segmented collectors to determine the angle between the normal to the collector and the arriving particle beam. From this information and a knowledge of the spacecraft attitude and velocity, the ambient drift velocity vector in a plane parallel to the collector surface can be determined. The gridded collimator and collectors are shown in cross-section in Figure 3. The entrance grid G1, the double collimator grid G3, the sensor outer shell, and the aperture plane in which the sensors are mounted are connected to sensor ground ($V_{aperture}$) during all operations. The repeller grid G2 may have different potentials applied to it depending upon the mode of the instrument. The shield grids G4 and G5 are held at $V_{aperture}$ for electrostatic shielding of the collectors and the suppressor grid G6 is held at -15 volts to ensure that no ambient electrons strike the collector surfaces and that photo-emission from the collector surfaces are returned to the collector.

In all velocity measuring modes the drift velocity parallel to the sensor face is determined from two mutually perpendicular velocity components along the X and Z axes indicated in Figures 3 and 4. The axis designation system used in the figures assumes that the spacecraft is despun with the X axis pointing toward the center of the earth and the Z axis perpendicular to the orbit plane. In this configuration we use vertical and horizontal or pitch and yaw to denote the velocity along the X and Z axes, respectively. Figure 4 shows the collector configuration and the square entrance aperture which provides a simple linear geometric relationship between the angle of arrival of the plasma in the X-Y and Y-Z planes, the vertical and horizontal ion velocities, and the currents to the collector segments. If a is the hori-

6

Y AXIS
(DIRECTION OF MOTION)

G1
G2
G3
G4
G5
G6
C

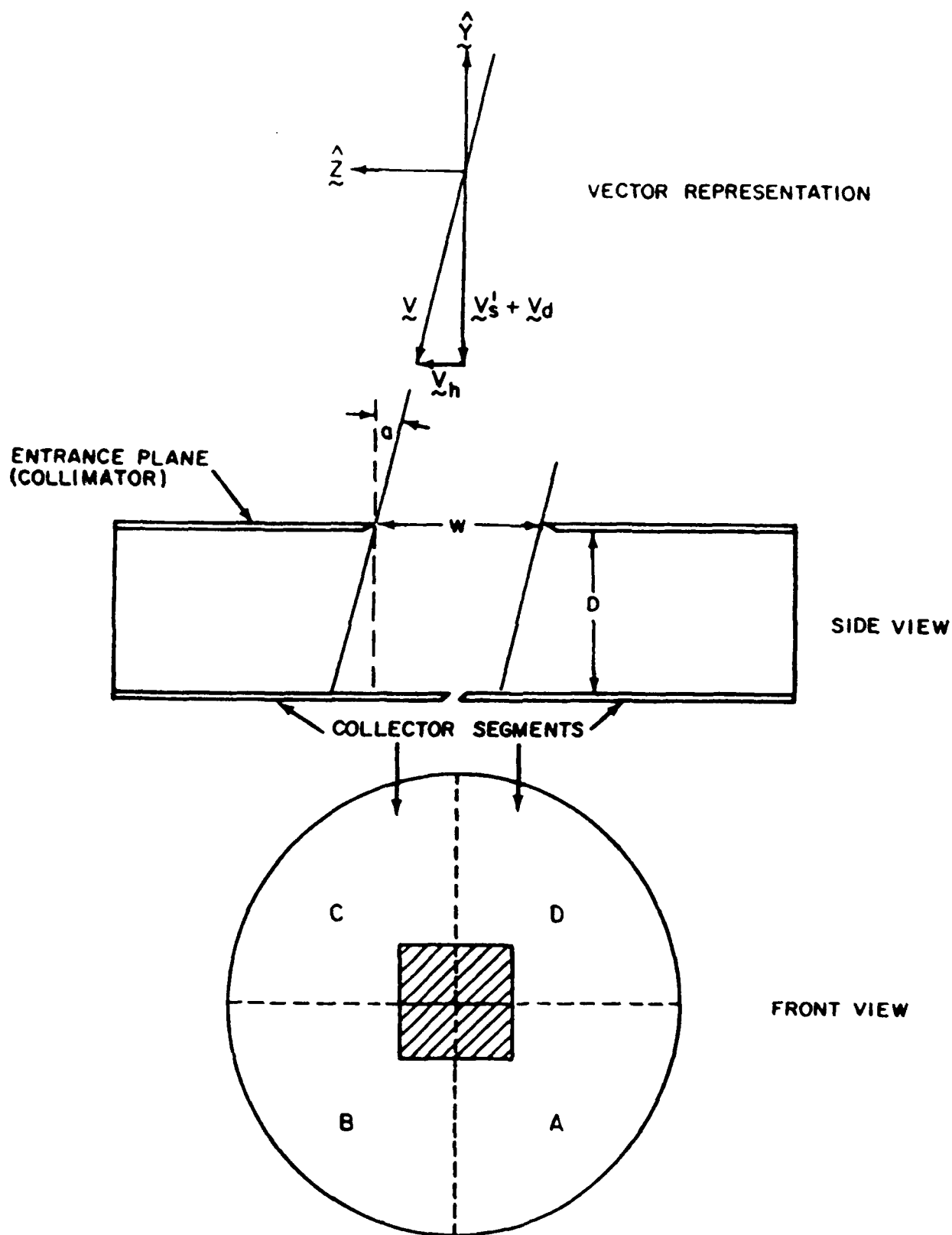☐ —INSULATOR

GRID DESIGNATORS

G1 - INPUT
G2 - H+REPELLER
G3 - COLLIMATOR
G4 - SHIELD
G5 - SHIELD
G6 - SUPPRESSOR
C - COLLECTOR PLATES

(ALL 50 LINES/INCH)

DRIFT SENSOR CROSS-SECTION

Figure 3

VECTOR REPRESENTATION

ENTRANCE PLANE
(COLLIMATOR)

SIDE VIEW

COLLECTOR SEGMENTS

FRONT VIEW

DM COLLECTOR / APERTURE CONFIGURATION

Figure 4

8

zontal arrival angle, then the horizontal ion velocity is given by

$$V_z = V_y \, Tan \; \alpha \tag{1}$$

where V_y is the sum of the spacecraft velocity along the Y axis of the spacecraft and the particle drift velocity along this axis. The current to the collector is proportional to the collector area illuminated and it can easily be shown that to first order the ratio of the currents on collectors A and D to the currents on collectors B and C is proportional to $Tan \; \alpha$.

The current ratio is determined by connecting each collector pair to a logarithmic amplifier (see Figure 5) that provides the input to a linear difference amplifier. The ratio is obtained by a technique called "rezero and offset" which is insensitive to possible imbalances in the log amplifiers. The sequence of operations is synchronized to the SSIES data format in all modes.

2.1.1 DM–NORMAL Mode

At the beginning of each Cycle 1 (see Figure 2), the log amplifier inputs are configured to measure vertical arrival angles with the zero switch (S10) closed. The input capacitor to A7 charges to a voltage proportional to the vertical ion arrival angle. The output of A7 is always translated by +2.5 volts (nominal) and the nominal +2.5 volt "rezero" level is telemetered on the Multiplex output for housekeeping purposes.

At the first Electrometer/Amplifier conversion pulse (Word #2), the circuit is switched to the offset configuration by opening S10 and reversing the inputs to the log amplifier. The voltage out of the filter (A6) goes to the opposite polarity but with the same amplitude. Since the capacitor has its original charge from the rezero measurement, and the new voltage from the filter is nearly equal but opposite, the voltage into A7 is twice the voltage corresponding

9
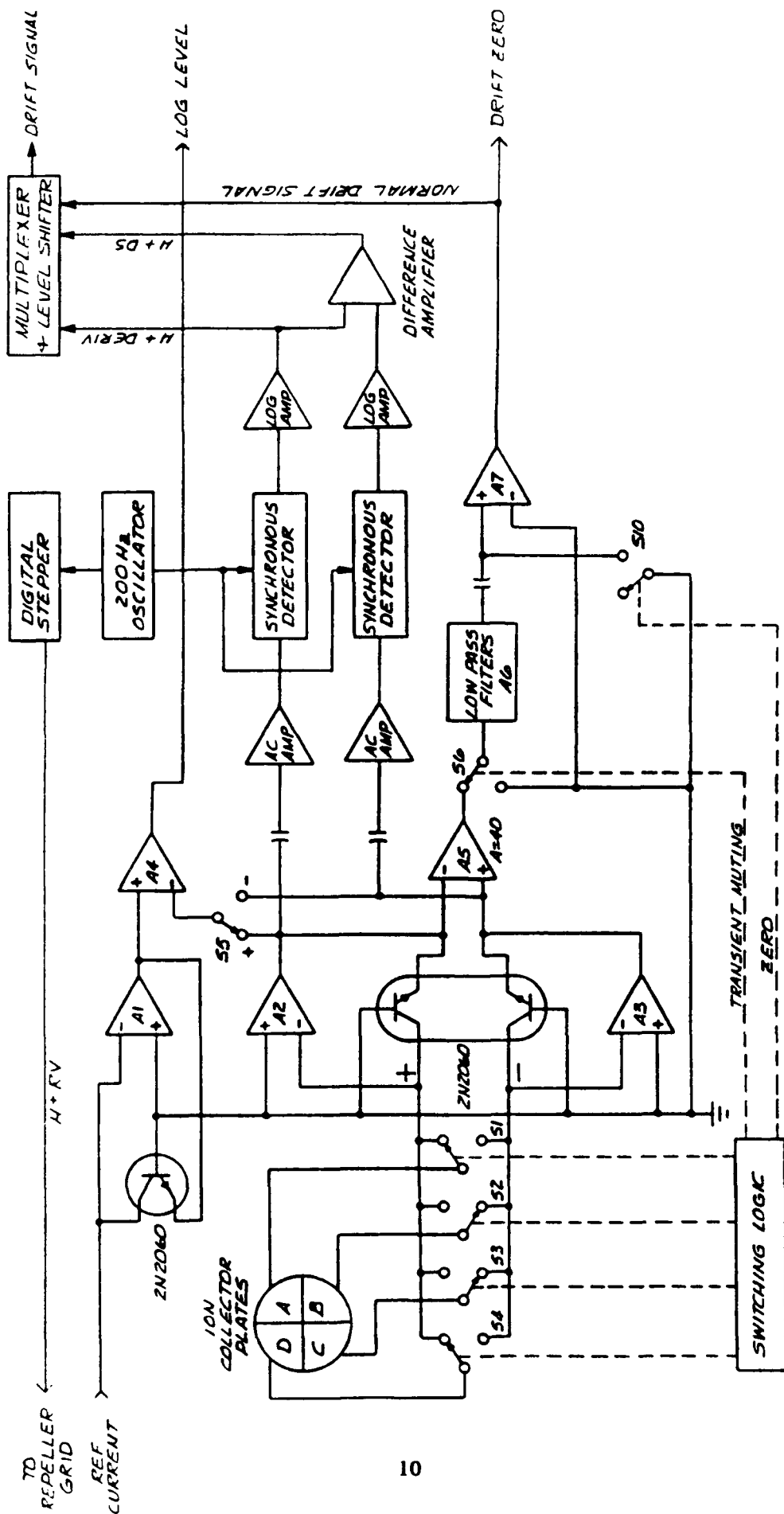
DRIFT METER FUNCTIONAL DIAGRAM

Figure 5

10

to the arrival angle. By measuring the sum of the two current ratios in this manner the result is insensitive to the characteristics of the two log amplifiers.
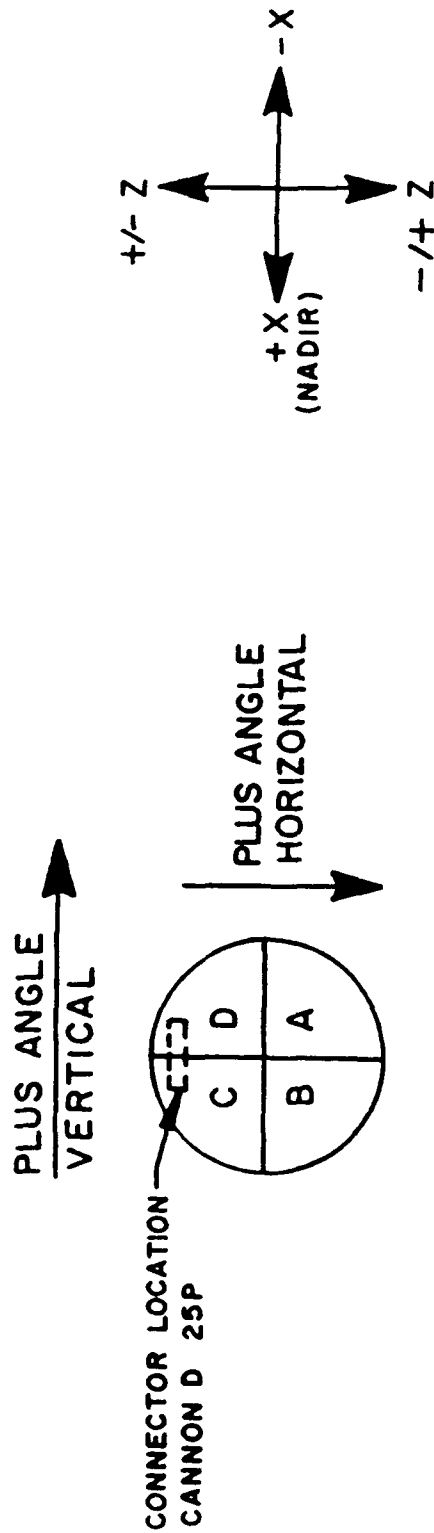
The vertical offset measurement is made at Word #6 (Drift Meter output), allowing ample settling time for transients generated by the collector switching. At the next Electro-meter Amplifier conversion pulse (Word #7), the collector pairs are connected to the log am-plifiers in the horizontal rezero configuration and the rezero and offset measurement se-quence is repeated. The rezero and offset sequence is repeated 12 times per second with alternate vertical and horizontal offset measurements taken and telemetered via downlink format words 49-60 (Figure 2A). Word 49 and alternate words in each second will therefore always be vertical measurements. The DM output is filtered by a 120 Hz. filter in this mode.

Figure 6 illustrates how to determine the ion drift direction from the DM output. By definition, ion drift velocities in the directions of the arrows generate "plus" angles. A "plus" angle gives a DM output above +2.5 volts (nominal) and a "minus" angle gives a voltage below +2.5 volts.

Since the presence of H^+ as a significant percentage of the ambient ions has been seen to compromise the O^+ arrival angle measurements, a fixed repeller potential may be selected for G2 (0 to +3 volts in 0.5 volt increments) to exclude H^+.

2.1.2 DM – H^+ Mode

The flow velocity of light ions along the earth's magnetic field lines is measured using the same principles described above. However, we must now accommodate the fact that the light ions will have a much smaller signal than the heavier ions because they have a smaller concentration and a larger thermal velocity. The larger thermal velocity of the light ions means that the constant of proportionality between the tangent of the ion arrival angle and

11

PLUS ANGLE VERTICAL

PLUS ANGLE HORIZONTAL

CONNECTOR LOCATION CANNON D 25P

D A
C B

+X (NADIR)

-X

+/- Z

-/+ Z

DRIFT METER
ARRIVAL ANGLE POLARITY DEFINITION

Figure 6

12

collector current asymmetry will not be the same as that established for heavy ions. The constant can be established, however, if the signal from the light ions can be extracted from the larger heavy ion signal. This is achieved utilizing a modulation technique originally employed in the RPA on the NASA Atmosphere Explorer satellite for electronically taking the derivative of the characteristic RPA curve.

This technique employs a retarding voltage (H^+RV) applied to the repeller grid G2. The positive DC potential on G2 can be varied stepwise from a selected starting point (0, 1, 2, or 3 volts) for 9 steps at 0.2 volts per step. In addition to the positive DC potential, a 200 hz. square wave is applied to G2. Since the heavy ions (mass 16 and above) have about 5 ev and above energy with respect to the spacecraft, their ability to reach the collector is not affected by the H^+RV, but the contribution to the total signal from H^+ ions is repeatedly diminished and returned at the square wave frequency. Since the repeller grid G2 is located in front of the collimator (aperture) the modulation on the grid will not affect the arrival angle of the heavy ions, so no compensation grid is required. Thus the log amplifier outputs (A2 and A3) will be modulated at 200 hz. and the amplitude of the modulation will be proportional to the collector surface areas illuminated by the H^+ ions. The ratio of these amplitudes is proportional to their arrival angles.

The modulated outputs of the log amplifiers are amplified and synchronously detected. The H^+ derivative (H^+DERIV) output provides a signal proportional to the amplitude of the H^+ modulation from which the H^+ concentration can be derived. The H^+ drift signal (H^+DS) output is derived by comparing the modulated log amplifier outputs in a difference amplifier and is proportional to the H^+ arrival angle, either horizontal (H) or vertical (V) depending on which pairs of collectors are connected to the log amplifiers.

13

The H$^+$ Mode measurement sequence is four seconds long and begins at a T$_0$ Cycle 1 that is coincident with a 16 SECSYNC pulse. During the H$^+$ sequence, the data is sampled at the sample format (Fig. 2) word numbers shown and is telemetered 12 times per second via words 49-60 in the downlink format shown in Figure 2A.

Sample Format Word #	Downlink Format Word #	Second 1,5,9, 13....	Second 2,6,10. 18....	Second 3,7,11, 15....	Second 4,8,12, 16....
6	49	Offset(V)	Offset(V)	Offset(H)	Offset(H)
16	50	Offset(H)	Offset(H)	Offset(V)	Offset(V)
26	51	H$^+$DERIV(H)	H$^+$DS(H)	H$^+$DERIV(V)	H$^+$DS(V)
36	52	H$^+$DERIV(H)	H$^+$DS(H)	H$^+$DERIV(V)	H$^+$DS(V)
46	53	H$^+$DERIV(H)	H$^+$DS(H)	H$^+$DERIV(V)	H$^+$DS(V)
56	54	H$^+$DERIV(H)	H$^+$DS(H)	H$^+$DERIV(V)	H$^+$DS(V)
66	55	H$^+$DERIV(H)	H$^+$DS(H)	H$^+$DERIV(V)	H$^+$DS(V)
76	56	H$^+$DERIV(H)	H$^+$DS(H)	H$^+$DERIV(V)	H$^+$DS(V)
86	57	H$^+$DERIV(H)	H$^+$DS(H)	H$^+$DERIV(V)	H$^+$DS(V)
96	58	H$^+$DERIV(H)	H$^+$DS(H)	H$^+$DERIV(V)	H$^+$DS(V)
106	59	H$^+$DERIV(H)	H$^+$DS(H)	H$^+$DERIV(V)	H$^+$DS(V)
116	60	H$^+$DERIV(H)	H$^+$DS(H)	H$^+$DERIV(V)	H$^+$DS(V)

At the beginning of each cycle, vertical (V) and horizontal (H) offset measurements are made as in the bulk motion measurements. The H$^+$ RV is held at the selected starting point until the end of sample #3. After sample #3 and subsequent samples, the H$^+$ RV is incremented by 0.2 volts. The 200 hz. modulation is applied after sample #2. The H$^+$ DERIV and H$^+$ DS outputs

are sampled alternately in the horizontal and vertical configurations as shown above. A 120 Hz. output filter is used.

Either a high or a low modulation level may be selected by command. The low level provides 50 mv. peak to peak during the H^+ DERIV measurements and 400 mv. during the H^+ DS measurements. The high level provides 100 mv. for H^+ DERIV and 800 mv. for H^+ DS.

2.1.3 DM- Fiba Mode

In this mode the DM output is continuously connected to the normal drift signal as in the NORMAL mode, but the rezero and offset sequence is changed to accommodate the comb filter bank that is used to extend the bandwidth of the transverse drift velocity measurements. The sequence is as shown below where V_R and H_R are vertical and horizontal rezero measurements respectively. V_O and H_O are the offset measurements and V_D and H_D are "deviation" measurements.

| Sample Format Word #	Downlink Format Word #	Second 1,5, 9....	Second 2,6, 10....	Second 3,7, 11....	Second 4,8, 12....
6	49	V_D	H_D	H_D	V_D
16	50	V_D	H_D	H_D	V_D
26	51	V_D	H_D	H_D	V_D
36	52	V_D	H_D	H_D	V_D
46	53	H_R	H_D	V_R	V_D
56	54	H_R	H_D	V_R	V_D
66	55	H_O	H_D	V_O	V_D
76	56	H_O	H_D	V_O	V_D
86	57	H_D	H_D	V_D	V_D
96	58	H_D	H_D	V_D	V_D
106	59	H_D	H_D	V_D	V_D
116	60	H_D	H_D	V_D	V_D

15

The rezero and offset measurements are made as described in 2.1 above for the NORMAL mode. After the last offset reading is taken (word #76), the collectors are returned to the rezero configuration, but the zero switch (S10) is left open until the next rezero sequence. The deviation measurements will therefore reflect any change in collector current ratio from the offset reading.

A 30 Hz. output filter is used during the rezero and offset readings and a 6 Hz. filter is used during deviation measurements.

To extend the bandwidth of the measurements, the output of A5 is AC coupled to a wide band ranging amplifier (WIBAN2) and then to a series of six bandpass filters and logarithmic amplifiers (Figure 7). WIBAN2 has 5 linear sensitivity ranges differing by a factor of $\sqrt{10}$ for each range change. The WIBAN2 sensitivity range can be automatically determined by the filter channel with the largest output voltage or fixed by ground command. In the automatic ranging mode, WIBAN2 is allowed to range during a window beginning at word #77 in odd seconds and ending at word #27 in even seconds (sample format word numbers). Ranging is disabled at all other times.

The bandpass filter frequencies are given below where the width of each filter is a factor of 2.4 between the 6 db. points:

Filter	Bandwidth
FIBA1	12 – 29 hz
FIBA2	29 – 69 hz
FIBA3	69 – 166 hz
FIBA4	166 – 398 hz
FIBA5	398 – 956 hz
FIBA6	956 – 2293 hz
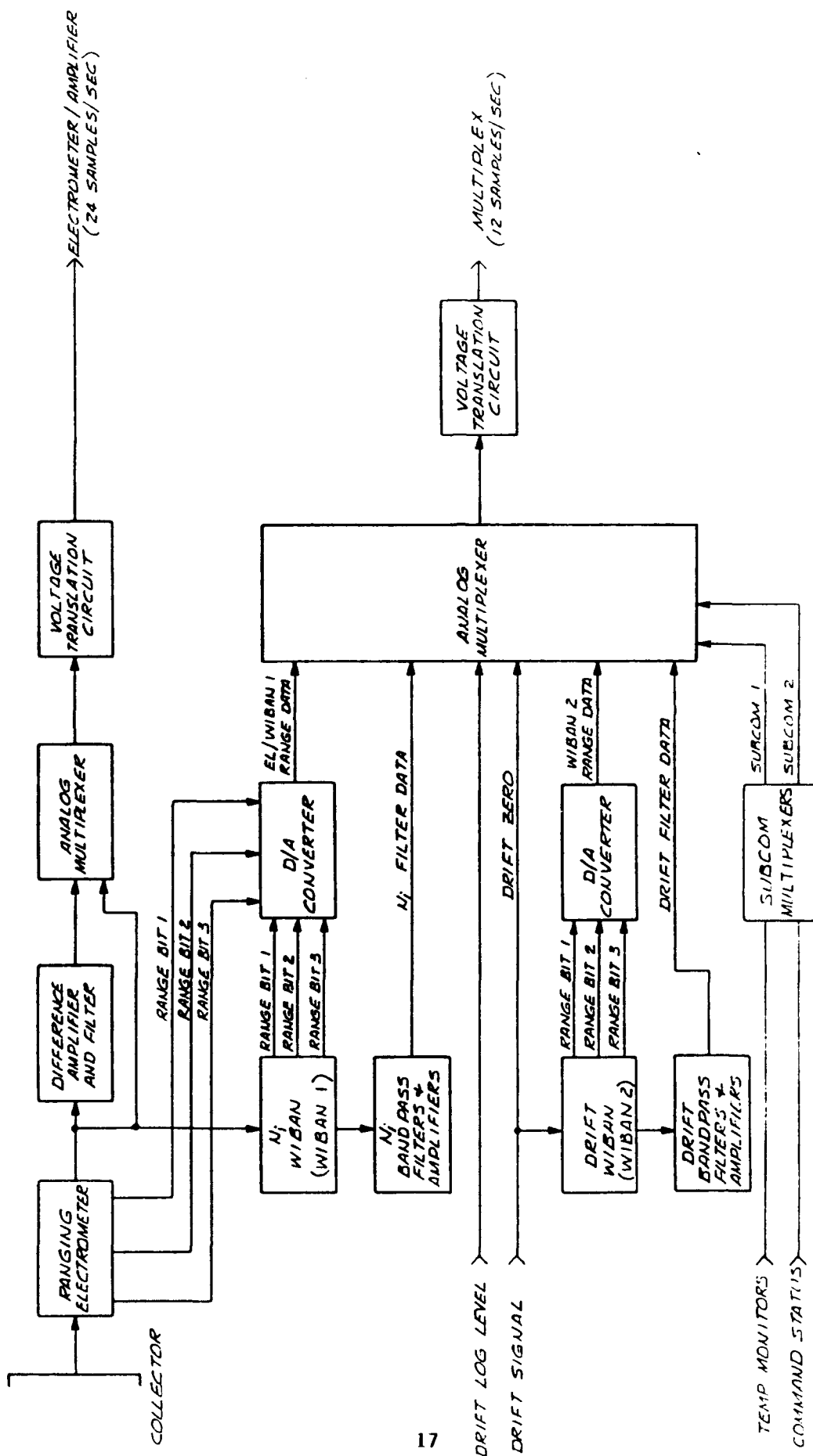
SCINTILLATION METER / MULTIPLEX BLOCK DIAGRAM

Figure 7

17

Each filter circuit consists of a logarithmic amplifier preceded by an active bandpass filter. Each log amplifier provides an output proportional to the log of the rms of the input signal. The useful dynamic range of each log amplifier is approximately 50 db with a sensitivity of 1.5 volts per decade (nominal). The filters are sampled once every two seconds on the MUX output as discussed below.

2.2 Scintillation Meter

The Scintillation Meter (SM) sensor is illustrated in Figure 8. The double input grid G1 is fixed at the $V_{aperture}$ potential. Grid G2 serves as an electron suppressor for the collector and also as an electron repeller for ambient electrons. Grid G3 provides electrostatic shielding for the collector. The collector is connected to a linear electrometer that measures the total ion current impinging on the collector (Figure 7). The electrometer has 5 linear sensitivity ranges and the sensitivity is automatically adjusted to maintain maximum sensitivity while staying within the telemetry band. The electrometer sensitivity on the most sensitive range is 6.32×10^{-9} amps/volt and decreases by a factor of $\sqrt{10}$ for each range change to 6.32×10^{-7} amps/volt on the least sensitive range.

In order to achieve higher sensitivity to change in N_i, the electrometer output is stored periodically at one terminal of a x10 difference amplifier and the live electrometer output is connected to the other terminal. The zero output of the difference amplifier is set to the middle of the telemetry band so that either positive or negative changes in N_i can be detected.

An analog multiplexer is used to automatically connect either the electrometer or amplifier to the telemeter (via a 12 hz Bessel filter) depending on the magnitude of the variations in N_i. The analog multiplexer is controlled by comparator circuits that monitor the amplifier output to determine if it is near the upper or lower telemetry band edge. When the amplifier

18

Y AXIS
(DIRECTION OF MOTION)

7 cm DIA

G1

G2

G3
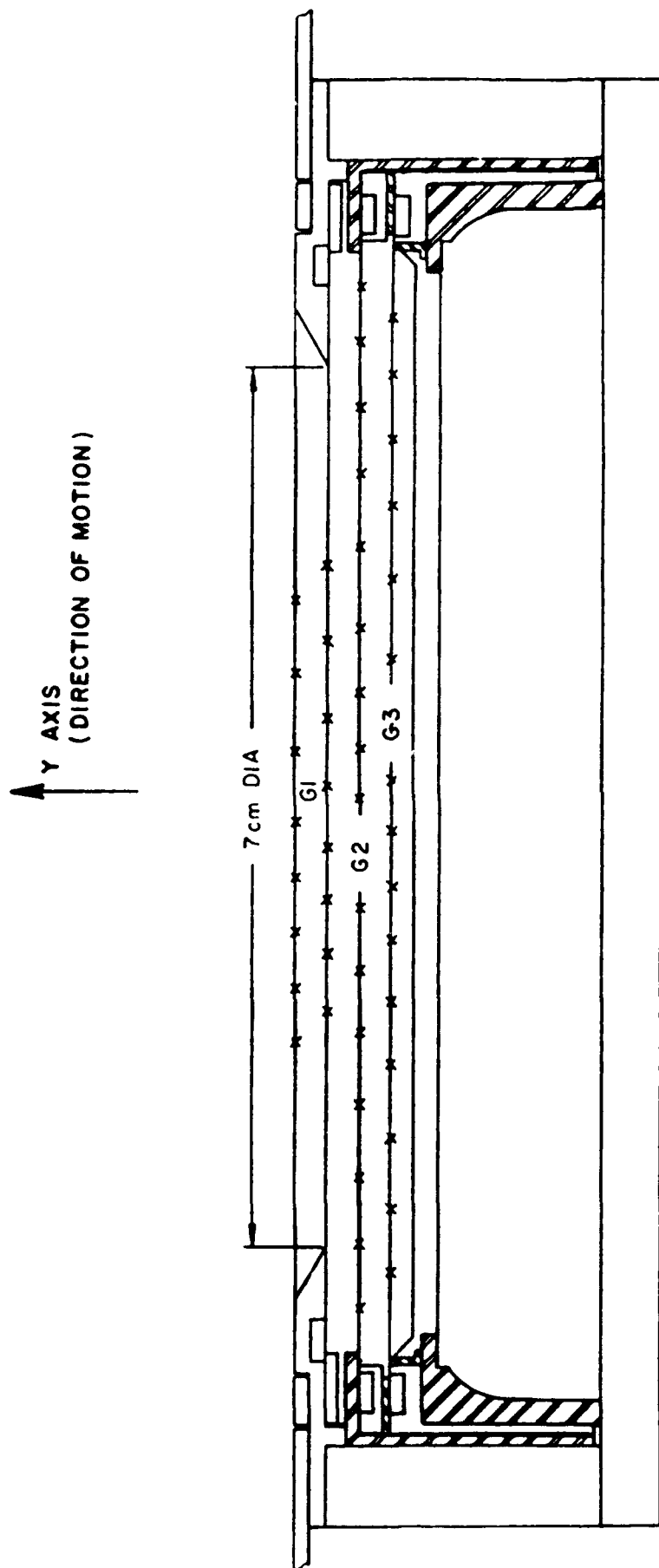
✕ – INSULATOR

GRID DESIGNATORS

G1 – INPUT (DUAL)
G2 – SUPPRESSOR   (ALL 50 LINES / INCH)
G3 – SHIELD

APERTURE – 38.5 cm²
TRANSMISSION = 0.663
A_{eff} = 25.53 cm²

SCINTILLATION METER SENSOR CROSS-SECTION

Figure 8

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exceeds either the upper or lower comparator limit, the electrometer is connected to the telemeter. (The amplifier is "zeroed" to the nominal + 2.7 volt level continuously while the electrometer is connected to the telemeter.) If the amplifier again exceeds either comparator limit within one second, the electrometer is connected continuously to the telemeter until 8 T_0 cycle 1 pulses have elapsed (15 to 16 seconds). At the end of this period, the output is switched back to the amplifier. If over-range occurs again within 1 second, the output is switched back to electrometer for another 15 to 16 second period. If over-range does not occur during the 1 second period, the words remain on the amplifier until one of the following events occurs:

1. An amplifier over-range will switch the output to electrometer. The next T_0 CYCLE 1 pulse will initiate a new cycle.

2. After a 16 second period, the output is switched to electrometer for 2 samples.

The above events are flagged when they occur as follows:

EVENT	FLAG	DURATION
Amplifier to electrometer with no electrometer range change	0 volts	Either 1 or 2 samples
Electrometer range change (always causes an amplifier to electrometer switch)	Range Data (See below)	Either 1 or 2 samples
Electrometer to amplifier	+ 5.11 volts	1 sample

Whenever the electrometer changes range, a voltage level indicating the new range setting is output as indicated above (The range setting is also telemetered once every two seconds on the Multiplex output). The nominal output voltage levels versus electrometer range are as follows:

20

	Range	Nominal Voltage Level
1	6.32x105–94 A/V	0.26
2	2x105–84 A/V	0.22
3	6.32x105–84 A/V	0.20
4	2x105–74 A/V	0.16
5	6.32x105–74 A/V	0.12

(Note: The lower comparator limits are set above 0.26 volts and the upper comparator limits are set below 5 volts. This provides virtually unambiguous flag and range data since the amplifier output is constrained between the comparator limits as is the electrometer except for the bottom of range one and the top of range 5.)

The bandwidth of the ionospheric irregularity measurements is extended by AC coupling the electrometer output to a wide band ranging amplifier (WIBAN1) and then to a series of 6 bandpass filters and logarithmic amplifiers identical to those descibed for the Drift Meter above. WIBAN1 is allowed to range automatically from sample format word #61 to word #107 in each odd numbered second. Each filter output is sampled once per second on the MUX output.

2.3 Multiplex Output

Figure 7 shows a block diagram of the Multiplex (MUX) function and Table 1 defines the data multiplexing and sample times within the SSIES-2 data sample format (Figure 2) for each 128 second data block and the corresponding data downlink word numbers (Figure 2A). The outputs labelled N_iFIBAn and DMFIBAn are the outputs of the bandpass filters and amplifiers connected to the SM and DM respectively as previously discussed.

TABLE 1

DSM2 MULTIPLEX DATA

SAMPLE WORD #	DOWNLINK WORD #	*Odd Seconds 1,3,5,....	*Even Seconds 2,4,6,....
10	61	DM FIBA 6	Subcom 1
11	62	DM FIBA 4	Subcom 2
20	63	DM FIBA 2	Log Level
21	64	DM FIBA 5	Drift Signal
30	65	DM FIBA 3	EL/WIBAN1 Range
31	66	DM FIBA 1	WIBAN2 Range
40	67	N_iFIBA 6	N_iFIBA 6
41	68	N_iFIBA 4	N_iFIBA 4
50	69	N_iFIBA 2	N_iFIBA 2
51	70	N_iFIBA 5	N_iFIBA 5
60	71	N_iFIBA 3	N_iFIBA 3
61	72	N_iFIBA 1	N_iFIBA 1

*Second #1 begins at a 16 SECSYNC pulse.

SECOND #	SUBCOM1 (DOWNLINK WORD #61)	SUBCOM2 (DOWNLINK WORD #62)
2,18,34, . . .	REG3A	REG3B
4,20,36, . . .	REG3C	REG3D
6,22,38, . . .	REG2A	REG2B
8,24,40, . . .	REG2C	REG2D
10,26,42, . . .	REG1A	REG1B
12,28,44, . . .	REG1C	REG1D
14,30,46, . . .	SENSTEMP	ELECTEMP
16,32,48, . . .	COMDATD (FIBA MODE)	RELAYFLG

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The EL/WIBAN1 range signal is a discrete voltage that indicates the sensitivity ranges of the SM electrometer and WIBAN1. The nominal output voltages versus ranges are as follows:

Electrometer Range

		1	2	3	4	5
WIBAN1	1	3.88	3.78	3.68	3.58	3.48
RANGE	2	3.08	2.98	2.88	2.78	2.68
	3	2.28	2.18	2.08	1.98	1.88
	4	1.49	1.39	1.29	1.19	1.09
	5	0.70	0.60	0.50	0.40	0.30

The nominal WIBAN2 Range output voltage versus WIBAN2 sensitivity range settings are:

WIBAN2 RANGE	OUTPUT VOLTAGE
1	0.00
2	0.27
3	0.54
4	0.80
5	1.08

The Drift Signal output is included as a housekeeping monitor of the nominal 2.5 volt DM rezero level in the NORMAL mode. In the other modes it is not sampled in the rezero configuration.

The Log Level signal monitors the DM log amplifier outputs primarily for housekeeping purposes. It can also be used to derive ion concentration. The DM mode determines which collectors are connected to the log amplifier inputs as shown in the following matrix:

MODE	Second 2,6,10,14, . . .	Second 4,8,12,16, . . .
NORMAL	LLA, B&C	LLB, A&D
H+	LLA, A&B	LLB, B&C
FIBA	LLA, C&D	LLB, A&D

The Subcom1 and Subcom2 outputs provide sensor and electronics temperature monitors, a flag for the SENPOT relay ($0V = V_{BIAS}$ mode, $+5.11V = $ SENPOT mode), the status of the DSM2 internal command registers and the status of the COMDATD line that is latched by the SSIES-2 main electronics package (MEP). The command register states versus commands are given in the following section.

2.4 Commands

The SSIES-2 receives the serial commands from the spacecraft. When a DSM2 command is detected, it is sent to the DSM2 via a four-line parallel data bus (COMDATA,B,C,D) and a three-line address bus (REGSTROBEA,B,C). The data on the COMDAT bus is stored in one of the three DSM2 command registers as shown in Table 2 when one of the REGSTROBE bits is asserted. After the data is stored in the register, the REGSTROBE bit is removed before the COMDAT data is changed to preclude disturbing the stored register contents.

The data stored in register 1 is used to control WIBAN2 range as previously discussed and the data in register 2 is used to control WIBAN1 range and the SENPOT/VBIAS mode latching relay. When one of the two relay commands is detected by the MEP, the command

TABLE 2

DSM2 COMMAND DEFINITION

| REGSTROBE			COMDAT				MNEMONIC
C	B	A	D	C	B	A	
0	0	1	0	0	0	0	WB2AUTO
0	0	1	1	0	0	0	WB2RNG1
0	0	1	1	0	0	1	WB2RNG2
0	0	1	1	0	1	0	WB2RNG3
0	0	1	1	0	1	1	WB2RNG4
0	0	1	1	1	0	0	WB2RNG5
0	1	0	0	0	0	0	WB1AUTO
0	1	0	1	0	0	0	WB1RNG1
0	1	0	1	0	0	1	WB1RNG2
0	1	0	1	0	1	0	WB1RNG3
0	1	0	1	0	1	1	WB1RNG4
0	1	0	1	1	0	0	WB1RNG5
0	1	0	1	1	0	1	SENPOT MODE
0	1	0	1	1	1	0	VBIAS MODE
1	0	0	0	0	0	0	DREP00
1	0	0	0	0	1	0	DREP10
1	0	0	0	0	1	1	DREP15
1	0	0	0	1	0	0	DREP20
1	0	0	0	1	0	1	DREP25
1	0	0	0	1	1	0	DREP30
1	0	0	1	0	0	0	0WIGLO
1	0	0	1	0	0	1	0WIGHI
1	0	0	1	0	1	0	1WIGLO
1	0	0	1	0	1	1	1WIGHI
1	0	0	1	1	0	0	2WIGLO
1	0	0	1	1	0	1	2WIGHI
1	0	0	1	1	1	0	3WIGLO
1	0	0	1	1	1	1	3WIGHI
0	0	0	1	0	0	0	FIBA MODE
0	0	0	0	0	0	0	NORMAL/H$^+$ MODE

is sent to register 2. After a time period sufficient to ensure that the relay is magnetically latched, register 2 is restored by the MEP to the state that was present prior to the execution of the relay command.

Register 3 is used in conjunction with the COMDATD line (the COMDAT lines are latched by the MEP) to establish the DM operating mode. If COMDATD is a logic "1", the FIBA mode is commanded and a fixed H^+ repeller voltage (DREP00–DREP30) must be selected and stored in register 3 to repel H^+ ions. (Note: The H^+ repeller voltage commands, 0WIGLO through 0WIGHI are not gated out by the hardware in the FIBA mode but should not normally be selected in this mode. These commands would only be useful in the FIBA mode as a diagnostic tool and should not be included in operational FIBA mode sequences.) If COMDATD is low and one of the fixed H^+ repeller voltage (DREP00–DREP30) is selected, the DM operates in the NORMAL mode. The DM is in the H^+ mode when COMDATD is low and one of the H^+ modulated voltage ramps (0WIGLO–3WIGHI) is selected and stored in register 3.

At power up and reset, the MEP initiate procedure automatically sets the registers and the latched COMDAT lines to all "0", i.e., WB2AUTO, WB1AUTO, DREP00, NORMAL/ H^+ mode.

2.5   Sensor Potential

Figure 9 illustrates the SENPOT circuit that is included as an auxiliary means of establishing sensor potential. The reference surface is a segment of the aperture plane located near the Irregularity Sensor that is insulated from the sensor housings and insulated from the other part of the aperture plane. The main part of the aperture plane is tied electrically to the ion sensor housings. The reference surface is sized to collect enough ion current to com-
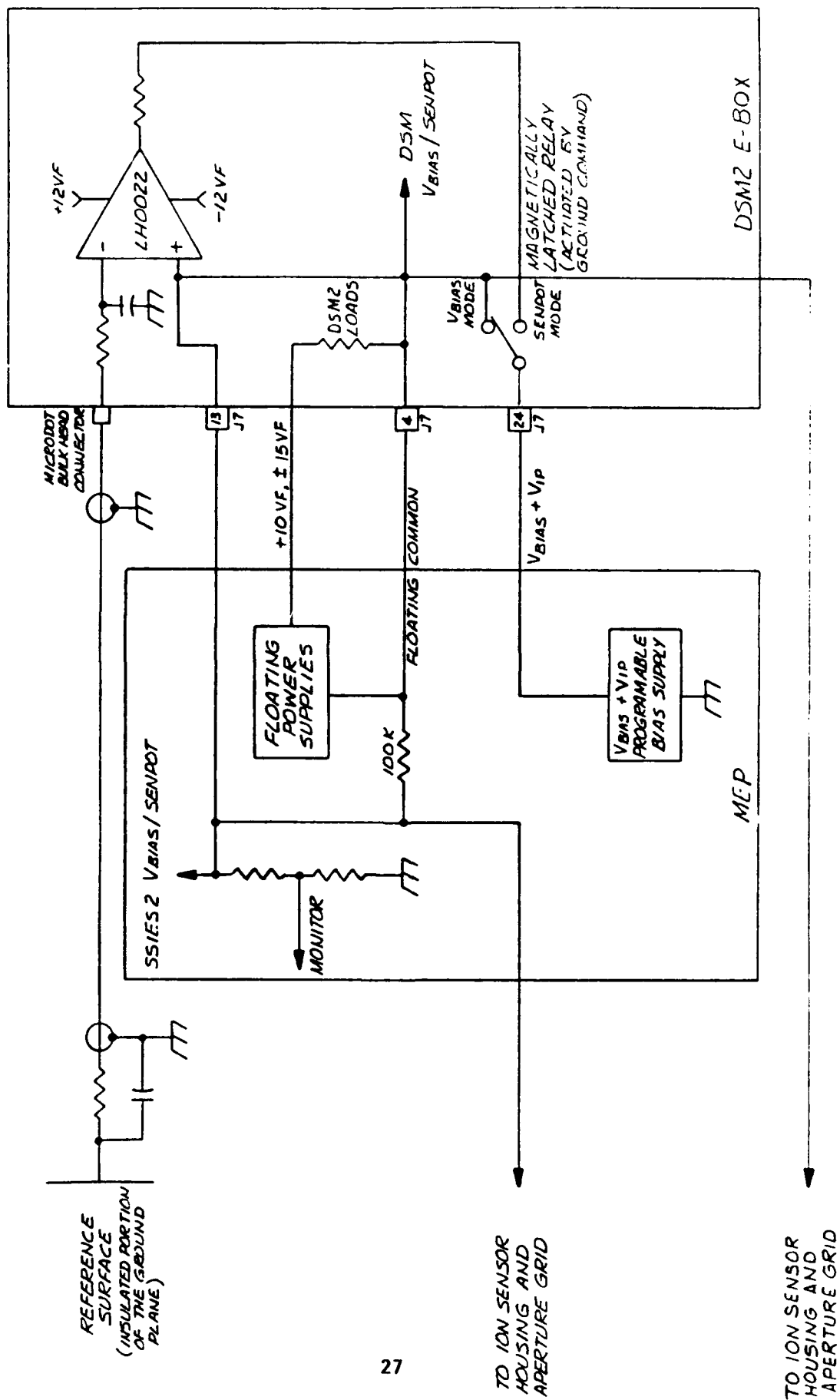
DSM2 SENPOT CIRCUIT

Figure 9

fortably allow the SENPOT circuit to operate over the available voltage range ($=-12$ volts to $+37$ volts) with an ion density of $> 100 \, cm^{-3}$ and a reference surface insulation resistance of $> 10^{11}$ ohms.

The reference surface is connected to the non–inverting input of an FET–input operational amplifier that is powered by floating supplies referenced to the sensor potential. The high input impedance and low input bias current of the op–amp allows the ground plane to float at the potential at which equal ion and electron currents are collected. nominally –1 volt with respect to plasma potential. Since the op–amp must maintain equal voltages at both inputs. it will drive against the spacecraft ground (through the SSIES VBIAS + VIP supply connected to the op–amp output) until the voltage at the non–inverting input is at the ground plane potential. Since the output voltage swing of the op–amp is about $C=9$ volts. the VBIAS + VIP supply connected to the output allows control of the sensor potential from about –12 volts to +37 volts with respect to spacecraft potential.

2.6 Mass/Weight

The measured mass/weight for the listed flight configuration instrument components are:

	Grams	Pounds
Sensor Assemblies – DM	678.1	1.49
– SM	689.8	1.52
– RPA	405.7	0.89
Aperture Plane	415.6	0.92
Sensor Mounting Bracket	289.6	0.64
Miscellaneous Hardware	48.4	0.11
Total Ion Sensor Array	2527.2	5.57
DSM Electronics Box	2553.7	5.62

2.7 Power Supplies

The SSIES-2 provides regulated voltages to the DSM2. The regulated voltages versus drain currents at 25°C are:

$$+ 12VF - 55 \text{ ma.}$$

$$-12VF - 55 \text{ ma.}$$

$$+ 12V - 1.5 \text{ ma}$$

$$-12V - 1.5 \text{ ma.}$$

The increase in current due to temperature variations within the specified temperature extremes is less than 25%. The SENPOT relay coils draw about 25 ma. from the +12VF line when either the SENPOT mode or VBIAS mode command is asserted. These commands are only asserted for a short time by the SSIES-2 microprocessor to magnetically latch the relay and then the relay coil power is removed.

References

[1] Zuccaro, D. R., and B. J. Holt, "A Technique for Establishing a Reference Potential on Satellites in Planetary Ionospheres", *J. Geophys. Res.*, *87*, 8327 – 8329, 1982

SECTION 2

SPACECRAFT–LEVEL INSTRUMENT TESTING,

INSTRUMENT HANDLING AND SAFETY

SPACECRAFT-LEVEL INSTRUMENT TESTING,
INSTRUMENT HANDLING AND SAFETY

1.0 General

This section defines the three types of electrical tests planned for the DSM2 after installation on the spacecraft. Paragraph 5.0 indicates the times during the spacecraft-level test flow that the tests should be performed. The required sensor mechanical alignments versus spacecraft test flow are also indicated.

2.0 Electrical Performance Evaluation Test (EPET)

The EPET provides an automated test procedure for testing instrument response in each major operating mode. Although there are only three distinct DSM2 modes (FIBA. H^+ or NORMAL). there are other modal parameters that may be selected by command. Each of the DSM2 commands should be executed at some point during the EPET and the command monitor checked to verify each command. Additionally, several tests will be defined for the EPET wherein the DSM2 is commanded to a specified mode. 32 consecutive seconds of data are stored and the data are printed out in a specified format. The instrument performance evaluation will be based on visual observation of the printed data. The EPET can be performed either with or without stimulation.

The time required for the EPET will be primarily determined by the speed of the spacecraft ground check-out computer system.

3.0 Stimulation

A battery powered stimulation unit is used to provide test currents to the DSM2 sensors. The stimulation unit attaches to the protective covers that are installed over the sensor input apertures. The test currents are injected by probes that screw into the front face of the

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sensor and make contact with the collectors. The stimulation unit requires ~6 inches clearance in front of the sensor aperture plane for installation. The planned usage of the stimulation unit is limited to tests performed with attending UTD personnel. Installation or removal of the stimulation unit will require approximately 30 minutes.

4.0 Sensor Grid Test

The sensor grid test is performed by UTD personnel after final instrument installation on the spacecraft and completion of environmental testing. The test consists of attaching test probes to the internal sensor grids and verifying the correct grid potentials.

5.0 DSM2 Spacecraft-Level Test Requirements

SPACECRAFT ACTIVITY	INSTRUMENT TESTS REQUIRED
1. Instrument Integration	Initial Power Turn On (IPTO)
2. System Electrical Performance Evaluation Test (SEPET)	EPET With Stimulation
3. Temperature Testing	EPET
4. Vacuum Testing	EPET
5. Pre-vibration/Post-vacuum	Sensor Alignment
6. EMI/RFI Testing	EPET
7. Vibration Testing	EPET
8. Post-vibration	Sensor Alignment Check
9. Final Clean-up And Test	a. EPET With Stimulation
	b. Sensor Grid Test
10. Pre-shipment Tests	EPET
11. WTR Testing	EPET

6.0 Instrument Handling and Safety

6.1 Protective sensor covers should be utilized whenever sensors are installed (except during EMI and vibration testing) to prevent particulate contamination from entering the sensor entrance apertures and to prevent physical damage to the exposed entrance grids. Stimulus probes may be installed with the protective covers in place. Special gold-plated aperture covers are provided for thermal vacuum testing.

6.2 Most of the exterior of the instrument is painted with Chemglaze 306 flat black paint and should receive "white-glove" treatment and minimum handling. The Chemglaze paint is attacked (expanded) by almost all common cleaning solvents (alcohol, acetone, freon, Mek, etc.). UTD should be consulted prior to any proposed instrument cleaning operation.

6.3 Always minimize handling of gold plated surfaces and utilize approved gloves when handling is necessary.

7.0 Red Tag Items

The two protective covers over the sensor apertures will be removed at the latest practical time at WTR. Captive hardware (2-56 screws) is used for attaching the protective covers to the sensor face. After removal of the protective covers, gold plated 2-56 screws must be installed in the sensor face to fill the holes.

SECTION 3

DIAGRAMS, SCHEMATICS, DRAWINGS

DSM2 DRAWING LIST

– TOP ASSEMBLIES –

133–113   Sensor installation dwg.
133–704   Electronics box assy
PL133–704   ”   ”   ”
133–702   Scintillation Meter sensor head assy
PL133–702   ”   ”   ”   ”   ”
133–701   Drift sensor head assy
PL133–701   ”   ”   ”   ”
133–700   Ion sensor array
133–775   DSM2/SSIES–2 Intra–instrument cables

– SUBASSEMBLIES –

DSM2–1   Duct Ranging Amplifier
         Board assy   133–730
         Part list   PL133–730
         Schematic   133–728
         Wire list   133–732

DSM2–2   Wide Band Amplifier 1
         Board assy   133–711
         Part list   PL133–711
         Schematic   133–709
         Wire list   133–713

DSM2–3   Bandpass Amplifier – N$_i$FIBA 1,3,5
         Board assy   133–707
         Part list   PL133–707/3
         Schematic   133–162

DSM2–4   Bandpass Amplifier – N$_i$FIBA 2,4,6
         Board assy   133–707
         Part list   PL133–707/4
         Schematic   133–162

DSM2–5   Duct Amplifier and Logic
         Board assy   133–745
         Part list   PL133–745
         Schematic   133–743
         Wire list   133–747

DSM2-6   FIBA Amplifiers
        Board assy   133-716
        Part list   PL133-716
        Schematic   133-714

DSM2-7   Analog Level Shifters
        Board assy   133-740
        Part list   PL133-740
        Schematic   133-738
        Wire list   133-742

DSM2-8   Interface Buffer
        Board assy   133-764
        Part list   PL133-764
        Schematic   133-762

DSM2-9   Bandpass Amplifier - DM Fiba 1,3,5
        Board assy   133-707
        Part list   PL133-707/9
        Schematic   133-705

DSM2-10 Bandpass Amplifier DM Fiba 2,4,6
        Board assy   133-707
        Part list   PL133-707/10
        Schematic   133-705

DSM2-11 Wide Band Amplifier 2
        Board assy   133-720
        Part list   PL133-720
        Schematic   133-718
        Wire list   133-722

DSM2-12 Drift H + Detector
        Board assy   133-735
        Part list   PL133-735
        Schematic   133-733
        Wire list   133-737

DSM2-13 Drift Ranging Amplifier
        Board assy   133-759
        Part list   PL133-759
        Schematic   133-757
        Wire list   133-761

DSM2—14 Drift Amplifier
        Board assy   133—755
        Part list   PL133—755
        Schematic   133—753

DSM2—15 Drift Electometer
        Board assy   133—750
        Part List   PL133—750
        Schematic   133—748

DSM2—16 Duct Electrometer
        Board assy   133—725
        Part list   PL133—725
        Schematic   133—723